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Purification of Oysters in Simple Pits

BY

H. A. COLE

Ministry of Agriculture and Fisheries,
Fisheries Experiment Station, Conway,
North Wales

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PURIFICATION OF OYSTERS IN SIMPLE PITS

1. INTRODUCTION

e purification of oysters from sewage-polluted grounds has been accomplished at Brightlingsea, ., since 1934, employing a technique derived from experimental work at Conway by ıte H. Marshall Webb. A full account of this work has not been published, but brief descrip- of the technique employed have been given by Dodgson (1936) and Sherwood (1947). amentally the method is the same as that successfully employed for so long at Conway gson, 1928) for the cleansing of mussels. The principal modification introduced—the warming e seawater used to a minimum temperature of 54° F. (12·3° C.) to ensure the more rapid ge of water through the oysters than would be obtainable under normal winter conditions—s in a large increase in the capital cost of the installation, together with a substantial rise nning expenses. For this and other reasons, no further installations of the Brightlingsea type been built in Britain, although a very similar plant is in use at Tarbert Island, on the River non (Killeen, 1942). In view of the difficulties and expense of capital construction of all and the relatively high purification fee that is required if such plants are to be self-supporting, is little likelihood of further cleansing stations of this type being erected in the near future.

e need for a simpler technique than that used at Brightlingsea is shown by the number of d-circuit storage and cleansing plants erected privately at Whitstable, in London and in wall. These plants depend upon the constant re-use of natural or artificial seawater, passed g circulation through a patent filter. The oysters are held in small wooden tubs or concrete . Ozone is used in some plants to sterilize the water during its passage round the system, has proved unreliable in use and, if present in more than minimal quantities, may interfere the filtering mechanisms of the oysters and cause substantial losses. In practice ozonizers been used less and less in these plants.

ese closed-circuit plants are relatively costly to provide and are difficult to maintain without ent skilled attention; their performance has not been sufficiently reliable to secure official nition as a means of cleansing shellfish from areas closed under the Public Health (Shellfish) lations, 1934. A large proportion of the oysters passed through these plants are free from ıs pollution before treatment, and, as will be shown later, the maintenance of oysters in sea- in which they can function normally is almost certain to result in an improvement in their ıry quality if re-pollution is avoided. It is, therefore, not surprising that, generally speaking, closed-circuit plants have served to provide clean oysters for the market. They also provide ble storage facilities—which are almost a necessity in London where oysters have to be available staurants, etc., at short notice.

ere remains a pressing need for a simple, cheap and reliable method of purification for use source, so that oysters may be marketed free from sewage contamination without substantial cost to the producer. It is believed that a satisfactory cleansing technique, using storage pits, as are already in use on most oyster fisheries, has been evolved. With slight modification pits may be adapted for purification. This cleansing technique is described below together the experimental results upon which it is based.

e assistance given by colleagues Dr. E. W. Knight-Jones and Mr. G. Duncan Waugh in ing through these experiments at Burnham-on-Crouch is gratefully acknowledged.

2. METHODS

ification experiments have been made in storage pits excavated in the saltings fringing the rivers Roach and Crouch. These pits are situated between high-water marks of neap and g tides, and their inlet pipes are arranged so that seawater enters automatically at each high except during periods of neap tides. On the inner end of each inlet pipe there is a clapper falls as the tide recedes, thereby closing the pipe and preventing the outflow of water. In on the seaward ends of the inlet pipes can be closed, if needed, by wooden plugs. The pits ually 1½ ft. to 2 ft. deep and the sides are boarded. The bottom may be of rammed chalk, or shell gravel laid directly on the clay of the saltings. Pits may be of any convenient size; used for experiment were from 20 ft. × 50 ft. to 20 ft. × 60 ft.

At high spring tides the level of the river rises above the top of the pits which are consequer flooded, together with the adjacent saltings, but, with a few exceptions specifically mentioned bel experiments were made at neaps when the tide did not reach the pits. During the period of r of these experiments, therefore, the pits served as simple tanks in which the seawater remai unchanged. Plate I shows a general view of the pits owned by the Ministry of Agriculture Fisheries at Paglesham, on the River Roach, in which most of the experiments were made; det of the interior of one of the pits are shown in Plates II and III. Formerly there were many hundr or possibly thousands of pits adjoining the oyster beds in Essex and Kent, but the majority are r disused. Stamp (1946) gives a graphic view of those at the mouth of the creeks adjacent to W Mersea, although the locality is not stated in the legend. These pits are used not only for stor of oysters prior to sale, but for wintering young oysters taken from grounds susceptible to fr and snow-water damage (see Cole, 1951).

All the oysters used in these experiments were taken from the Southward Laying in the Ri Crouch (Plate IV). The main sewer from Burnham-on-Crouch (population served *ca.* 3,400 winter, with substantial seasonal additions) discharges at high water about 250 yards on the stream side of the western boundary of this laying. The sewage is untreated. A recent survey the bottom deposits of the Southward Laying (Mistakidis, 1951) revealed that a considera deposit of sludge was occurring at its western end, while off the sewer mouth itself the botton deeply covered with black organic mud and oysters are absent.

Oysters for experiment were taken from this laying and placed in the pits at Paglesham. Usua they were about four years old, of small marketable size. No special precautions were taken handling these oysters other than those observed in good commercial practice. They were pla on the bottom of the pit, which was not specially prepared in any way. Experiments were usua begun as soon as the tides had declined sufficiently to ensure that the pits would not be floo but in some cases, where the weekend intervened, there was a period of a few days during wh the water had remained stagnant in the pits before the oysters were put in. Some oysters of e sample were placed in a sterile tin for bacteriological analysis at the commencement of e experiment. These, and all samples of oysters from the pits, were sent to Conway and w examined by the technique described by Clegg and Sherwood (1947). Samples of oysters w withdrawn from the pit two, four, and in a few instances six days after the commencement of experiment. No special precautions were taken in collecting the oysters, the implement emplo being a "didal". This is similar to a large Dutch hoe and has a wire-netting bag, in which oys are retained, attached to the blade. The blade is pushed along the bottom of the pit. No spe precautions were taken either to clean the didal or to prevent disturbance of the mud and a deposit on the bottom of the pit. The oysters were rinsed in the pit water and placed i sterile tin.

Some experiments were also made in pits belonging to a firm of oyster planters and situated the south shore of the River Crouch, opposite Burnham (Plate IV). These pits are within the a closed for the collection of oysters for direct sale by the order made by the Burnham-on-Cro U.D.C. in 1936 under the provisions of the Public Health (Shellfish) Regulations, 1934. They approximately one mile in a direct line from the Burnham sewer outfall. The construction a arrangements for filling these pits are similar to those of the pits at Paglesham.

A few experiments were made during spring tide periods when new water entered the pits tw a day, and these are described separately.

The Portuguese oysters (*Gryphaea angulata*) used in a few experiments were not native to Southward Laying but were relaid there for 48 hours or longer from other oyster grounds in River Crouch. During this period they would acquire the characteristics of the locality so far sewage pollution was concerned.

Water temperature in the pits at Paglesham was generally recorded by a thermograph givin continuous record, but on occasions this thermograph was not available. On such occasions temperatures given are those recorded in the main channel of the river at Paglesham or Burnha on-Crouch. In general, pit-water temperatures are slightly higher in summer and lower in wir than those in the river, but the differences do not usually exceed 1° C.

3. RESULTS

e Oysters

ble I gives a summary of the results of the examination at Conway of all samples of native rs purified in the pits at Paglesham, together with the prevailing water temperatures. The eratures given are the means of the maxima and minima recorded over the period of the iment. The majority of the experiments were made during periods of neap tides, when the in the pits was not renewed. A few experiments were, however, deliberately arranged at of spring tides when water from the river flowed into the pits at each tide. The results of experiments did not differ from those obtained at neap tides; all were equally satisfactory. occurrence of one or two faecal *Bacterium coli* per ml. of flesh in an occasional oyster has gnificance. Shellfish purified at Conway and Brightlingsea may contain such small numbers sidual organisms (Dodgson, 1928). In a remote situation such as Paglesham it is impossible clude the possibility that sea birds may visit the pits; they are innocuous from a public health of view unless they have flown direct from sewage farms or sewage outfalls; such an occurrence glesham is very unlikely.

TABLE I

Native oysters (*Ostrea edulis*) purified in pits at Paglesham

Faecal *Bacterium coli* per ml. of flesh

Date and state of tide	*Initial pollution*	*After 2 days in pit*	*After 4 days in pit*	*Mean water temp. ° C.*	
				Max.	*Min.*
uary 1949 (neaps) ..	0, 6, 4, 0, 0	2, 0, 0, 0, 0	0, 0, 0, 0, 0	5·6	3·8
uary 1949 (neaps) ..	2, 0, 0, 0, 0	0, 0, 0, 0, 0	0, 0, 0, 0, 0	4·5	3·3
y 1949 (neaps)	64, 30, 32, 18, 14	0, 0, 0, 0, 0	4, 0, 0, 0, 4	19·6	15·9
ober 1949 (neaps) ..	34, 4, 34, 22, 78	0, 0, 0, 2, 0	0, 0, 0, 0, 0	15·5	14·4
vember 1949 (neaps) ..	44, 18, 24, 12, 18	0, 0, 0, 0, 0	0, 0, 0, 0, 0	8·1	
uary 1951 (neaps) ..	0, 2, 2, 0, 2	0, 0, 0, 0, 0	*0, 0, 0, 0, 0	4·0	2·5
/ 1951 (neaps)	52, 2, 36, 42, 38	0, 0, 0, 0, 0	0, 0, 0, 0, 0	18·1	17·6
/ 1951 (neaps)	76, 40, 46, 50, 28	0, 2, 0, 0, 0	0, 0, 0, 0, 0	18·2	17·3
gust 1951 (springs) ..	400, 52, 72, 18, 40	4, 0, 0, 0, 0	0, 0, 0, 0, 0	18·3	17·2
rch 1952 (neaps) ..	4, 0, 4, 8, 0	0, 0, 0, 0, 0	*Experiment discontinued after 2 days*	10·2	9·4
rch, 1952 (springs) ..	12, 2, 6, 28, 22	0, 4, 0, 0, 0	0, 0, 0, 0, 0	7·5	6·0
ril 1952 (neaps) ..	4, 8, 6, 10, 12	0, 0, 0, 0, 2	0, 0, 0, 0, 0	14·4	11·5
gust 1952 (neaps) ..	6, 16, 28, 0, 10	0, 0, 0, 0, 0	0, 0, 0, 0, 0 * 5 days	20·9	20·2

e range of water temperatures experienced during these experiments was from 2·5° to 20·9° C., he full range encountered during normal years. Since the figures given represent the means ur readings taken on successive days the actual range of temperatures was slightly higher; inimum temperature recorded was 1·5° C., and the maximum 21·3° C. Higher and very ly lower temperatures are experienced occasionally in Essex, but nowhere else on the coast itain is the seasonal range of sea temperature as great.

certain experiments polluted oysters were also placed in a pit on the south shore of the River ch, kindly made available by Messrs. Smith Bros. As previously mentioned, these pits lie n the area closed in 1936 under the Public Health (Shellfish) Regulations. As no alternative ge pits were available, their loss has proved a very severe handicap which has prevented, until tly, the retail sale of oysters from the River Crouch. The distance in a direct line from the ham sewer outfall is approximately one mile. The results of purification experiments in these see Table II) did not differ in any way from those made at Paglesham; all the samples were actory after two days' treatment. The temperature range covered by these experiments was 6° to 18·3° C. There is no reason to suppose that experiments conducted outside this range l give any different result.

guese Oysters

rtuguese oysters (*Gryphaea angulata*) which are relaid annually in quantity in Essex were ed with equal facility, but some of the later experiments were complicated by the occurrence

TABLE II

Native oysters (*Ostrea edulis*) purified in pits at Burnham (S. shore)

Faecal *Bacterium coli* per ml. of flesh

Date and state of tide	*Initial pollution*	*After 2 days in pit*	*After 4 days in pit*	*Mean Water ter °C.*	
				Max.	*Mi*
July 1951 (neaps)	52, 2, 36, 42, 38	0, 0, 0, 0, 0	0, 0, 0, 0, 0	18·1	17·
July 1951 (neaps)	76, 40, 46, 50, 28	0, 0, 0, 0, 2	0, 0, 0, 0, 0	18·2	17·
August 1951 (springs) ..	400, 32, 72, 18, 40	0, 0, 4, 0, 0	0, 0, 0, 2, 0	18·3	17·
March 1952 (neaps) ..	4, 0, 4, 8, 0	0, 0, 0, 0, 0	*Experiment discontinued after 2 days*	10·2	9·
March 1952 (springs) ..	12, 2, 6, 28, 22	0, 0, 0, 0, 0	0, 0, 0, 0, 0	7·5	6·
April 1952 (neaps) ..	4, 8, 6, 10, 12	0, 0, 0, 0, 0	0, 0, 0, 0, 0	14·4	11·

of exceptionally severe weather and disastrous floods which were responsible for the death of m oysters in the pits and on the beds (Waugh, 1953).

The peak season for the sale of Portuguese oysters is usually around August Bank Holiday, sales occur throughout the year; there is no close season. These oysters breed to a limited ex in the warmer parts of England; those used for the experiments had settled in the rivers Cro or Roach.

Two purification experiments made in August and September 1952 respectively, at relati high water temperatures, gave normal results, and satisfactory cleansing was obtained after two d in the pit. A third experiment in December 1952, at water temperatures varying from 0·9 2·6° C., was also satisfactory.

In an experiment begun in the last days of December 1952, at a period of spring tides, very sli re-pollution of the clean oysters occurred when the pits were flooded; water temperatures w still very low and some of the oysters were becoming weak. During a further experimen January 1953, sub-zero water temperatures had been experienced immediately before the experim began, and a skin of ice had formed on the pits. In these conditions it was impossible after days to find oysters which were not weak or dying, yet even at these very low temperatures sc improvement apparently took place in the purity of the oysters during the first two days of experiment when the strongest were picked for sampling. Since it is impossible to devise a meth of purifying weak and dying oysters, except by heat sterilization, the results of this experiment of no great interest.

A further experiment, begun on January 26 and completed on January 30, was interfered w after two days' treatment by the unexpected flooding of the pits as the result of high winds. will be recalled that on January 31 disastrous floods occurred throughout the East of England. Sli re-pollution from the estuary appears to have occurred in the sample examined after four da but after two days the oysters were clean.

A further trial was made in late February in an effort to complete an additional experiment wh temperatures remained at about the normal minimum winter level, but the oysters had not recove from the bad effects of the vast quantities of silt present in the river in the vicinity of Paglesha as the result of the inundation of the neighbouring islands. It was impossible to find oysters good condition after two days in the pits and the majority were dead or dying. At this time v severe losses of oysters occurred in the rivers Roach and Crouch (Waugh, 1953).

Experiments in normal conditions were resumed in June and August 1953, when two series w completed with satisfactory results. Initial pollution was very low in the first of these, due possi to the cold spell experienced during the last few days of May and the first week in June. Ma readers will have personal experiences of this cold spell as memories of the Coronation.

The temperature range recorded during experiments with Portuguese oysters was from −(to 24·5° C. The minimum figures given in Table III are the means of four daily readings.

PLATE I. The oyster pits at Paglesham, River Roach, owned by the Ministry of Agriculture and Fisheries, in which most of the cleansing experiments were made.

Close-up of a section of an oyster pit showing the details of construction. The small pipe in the corner is an inter-connection between two adjoining pits.

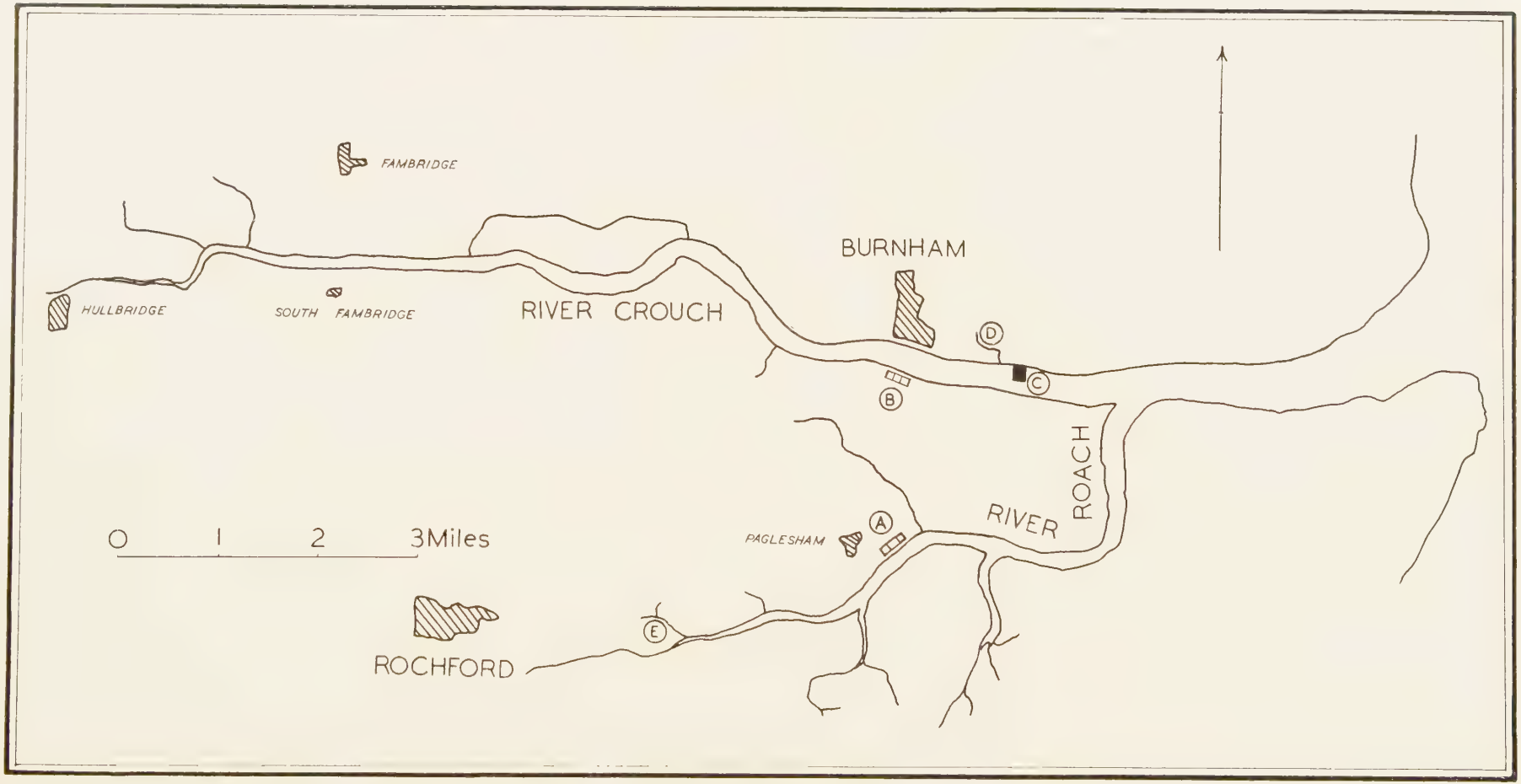

PLATE IV. The rivers Crouch and Roach, Essex, showing (A), the situation of the Ministry's oyster pits at Paglesham; (B), Smith Bros.' pits at Burnham, South Shore; (C), the source of polluted oysters used in the experiments, the Southward Laying; and (D and E respectively) the outfalls of the Burnham and Rochford sewers.

TABLE III

Portuguese oysters (*Gryphaea angulata*) purified in pits at Paglesham

Faecal *Bacterium coli* per ml. of flesh

te and state of tide	Initial pollution	After 2 days in pit	After 4 days in pit	Mean Water temp. °C.	
				Max.	Min.
ust 1952 (neaps) ..	40, 0, 34, 76, 8	0, 2, 0, 0, 0	0, 0, 2, 2, 0	20·2	19·1
ember 1952 (neaps) ..	30, 12, 4, 14, 26	0, 2, 2, 0, 0	0, 0, 0, 0, 0	14·8	13·9
mber 1952 (neaps) ..	34, 6, 6, 48, 0	0, 0, 0, 4, 0*	0, 0, 0, 0, 0†	2·6	0·9
mber 1952 (springs) ..	6, 26, 0, 12, 10	1, 0, 0, 1, 2	3, 4, 4, 0, 1	3·6	2·5
ary 1953 (neaps) ..	1, 3, 3, 2, 4	0, 1, 1, 0, 1	3, 5, 0, 4, 1‡	2·6	1·8
ary 1953 (neaps-springs)	1, 27, 8, 0, 9	0, 0, 0, 0, 0	1, 0, 0, 2, 2§	4·9	3·5
uary 1953 (neaps) ..	5, 7, 5, 21, 6	7, 1, 1, 5, 14‖	0, 0, 1, 1, 1	9·3	6·7
1953 (neaps)	5, 2, 1, 3, 3	0, 0, 0, 0, 0	0, 0, 0, 0, 0	15·9	12·8
ust 1953 (neaps) ..	21, 31, 29, 6, 14	0, 0, 0, 0, 0	0, 0, 0, 0, 0	24·5	20·7

* After 3 days.
† After 5 days.
‡ Oysters dead; ice on pits at beginning of experiment.
§ Pits flooded as result of high winds.
‖ Pit contained brood oysters, many dead and dying following floods.

4. SEASONAL VARIATION IN POLLUTION

interesting feature of these experiments has been the great seasonal variation in the initial ion of the oysters taken from the Southward Laying at Burnham. The significance of this on has not been appreciated in Britain, although in Canada and the northern Atlantic States U.S.A. it is realized that during the long, cold winter oysters are much less polluted, and in areas the collection of oysters for direct sale is permitted from grounds which are closed the warmer months. Samples of native oysters collected from the Southward Laying during ry in both 1949 and 1951 showed insignificant pollution, although coming from the immediate y of the sewer outfall, and they would have reached the standard of bacteriological purity ed at all inland markets (Sherwood and Scott Thomson, 1953). The oysters in these experi- showed improvement after two days in pits; faecal *B. coli* were absent after four days in all

In Fig. 1 (p. 8) the samples of native and Portuguese oysters are plotted against the month year, and it will be seen that initial pollution rises to a peak in August and then declines, ng a minimum in January and February. The samples are too few to show the complete , but it is clear that pollution is closely related to water temperature. Presumably tempera- erts its effect mainly on the rate of water filtration by the oysters, since it is reported (Vaccaro 1950) that faecal *B. coli* survive longer in sea water at low water temperatures. Macginitie has shown that lamellibranch molluscs may pass a current of water without feeding if con- are unfavourable, and there is clearly scope for further work on the behaviour of oysters in .

is been suggested that the rise and fall of pollution with the seasons results from an increase population of Burnham during the holiday season. Such an increase does occur, although not ery large scale, except during certain major sailing events in August and early September. hypothesis would not explain the rise in pollution during May and June nor its conntiuanec mparatively high level until December. Clearly, water temperature exerts the major influence

5. DISCUSSION

results show beyond all reasonable doubt that oysters can be cleansed satisfactorily from pollution, at all temperatures experienced in Britain, and with very simple equipment. uese and flat oysters behave similarly and cleanse themselves to an acceptable standard of in two days. Four days' treatment usually results in complete absence of faecal *B. coli* in f minced flesh.

ie River Roach at Paglesham, where most of the experiments were made, pollution is at all ery slight, the nearest sewage outfall being that from Rochford (population approx. 2,500),

about 3½ miles away. Samples of oysters taken from the river adjacent to the pits during months of November and December contained no oysters with more than one faecal *B. coli* per At high water the concentration of bacteria of sewage origin must be very low. In the River Cr experiments the concentration of sewage organisms at high water was higher as, except for a s period around high water at spring tides, the Burnham outfall is constantly liberating a virtu untreated effluent. At such times the river level is for a few hours above the level of the out

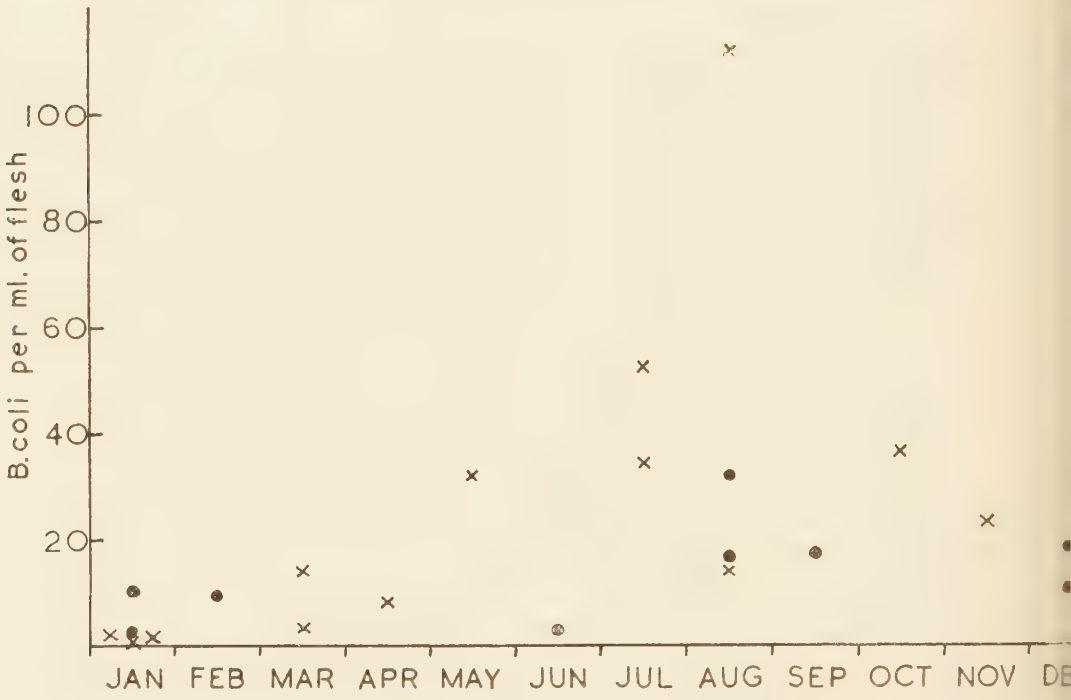

FIG. 1. Initial pollution of the oysters from the Southward Laying used in the experiments. × Natives; ● Portu

which is fitted with a tidal flap. The survey, which resulted in the application for a Closing under the Shellfish Regulations, included the examination of the pits on the south shore which the bulk of the sales of oysters at Burnham took place. The water entering the pits considered to be sufficiently polluted to justify their inclusion in the area covered by the C Nevertheless the water entering these pits at high tide would be judged on modern standards but lightly polluted. The pits are one mile from the outfall and the dilution must be consider since the river is ⅓ mile wide and there is a 3-knot current. The results of experiments in pits opposite Burnham differed in no way from those obtained using initially cleaner wate Paglesham and, indeed, no difference was expected since Dodgson (1928) showed that, at Con purification of mussels in tanks filled with highly polluted water which had not been treated proce to the same satisfactory end-point as in similar water after chlorination. Chlorination of heavily contaminated water was considered desirable but not essential. It thus seems that ev initially polluted water, mussels can cleanse themselves, presumably having first cleansed surrounding water.

Certainly there is a real difference between the contamination of oysters lying on a seabed, w they are continuously exposed to re-pollution, and that of oysters in a pit in which the wat isolated except for a short period around high tide. In such pits the period of possible re-pollu is short compared with the period of cleansing in the pit water, so that, in general, placing oy in pits is bound to result in an improvement in their degree of purity. Water enters the pits around high water, when the dilution of sewage effluent is normally at a maximum.

The entry of lightly polluted sea water from the river into the pits for a few hours at each did not materially affect the results in either set of pits. Very slight re-pollution occurred in Portuguese oysters, but their purity remained within the limits of Grade I as set by Sher and Scott Thomson (1953). Samples were, of course, collected after the tide had left the pits

cial precautions were taken to avoid collecting within a short period after the tide had receded. nalysis of oysters from storage pits in another locality in Essex, which are also exposed to pollution at high spring tides from nearby houseboats, confirms the conclusion that any small nt of pollution entering the pits with the tide very quickly disappears from the oysters, when lution is prevented by the falling tide. Two samples from this locality examined in August during a period of spring tides, were both free from faecal *B. coli* in 1 ml. of flesh. The rapid rification of oysters in pits, even in close proximity to sources of pollution, has not previously ully appreciated.

highly satisfactory results obtained in pits, in cleansing experiments at Paglesham and am, are supported by a substantial body of evidence obtained in other localities. On the Yealm, South Devon, four cleansing trials were made by my colleague Mr. P. R. Walne 1952 in a concrete pit of 200 gal. capacity, using 300 native oysters on each occasion. In trials faecal *B. coli* were absent in 1 ml. of flesh in samples of five oysters examined individually our days' treatment. Water temperatures varied from 9·5° to 12·8° C. during the course work. The water used was pumped in at high water, the pit being sited above high water ing tides. The river is subject to sufficient pollution to render it unwise to market oysters without treatment. Subsequently several batches of oysters have been purified by the oyster ant working the layings. A summary of the results and a description of the technique used en given by Peirson (1952). Other isolated purification experiments in pits made in various ies have all been given highly satisfactory results, e.g., in November 1952 a sample of highly ed oysters from the River Lynher was placed in a small tank in the Plymouth laboratory of arine Biological Association in water from the aquarium circulation. Complete absence of *B. coli* in 1 ml. of flesh was obtained in 48 hours in the five oysters examined.

ocalities where the water may be heavily polluted even at high tide, initial chlorination of the used for cleansing is considered desirable. At Fowey, in Cornwall, a pit-cleansing plant ying chlorinated water has been used with complete success for three seasons and a very ntial number of oysters have been purified (Baird, 1954, *in the press*). All results have been mly successful. The water is not warmed but the pits are under cover. The Fowey estuary er seriously polluted owing to the discharge of crude sewage from Lostwithiel into its head-

sum of all this evidence points to the conclusion that the very simple technique of cleansing yed is fully adequate in all circumstances likely to be experienced on British oyster beds. It e wondered why it was considered necessary to adopt a more complex and expensive technique only British oyster purification station so far established. The Brightlingsea technique is, ntials, the mussel-cleansing technique of Dodgson (1928), modified to deal with what were ered to be the special requirements of oysters. The most important of these was the warming water in winter, to spring or autumn temperatures, to secure an increased rate of water on. It was, apparently, not appreciated that oysters are much more lightly polluted at low ratures and that, although their filtration processes are slowed down, they are by no means d, and still suffice to free the gut and mantle cavity of sewage bacteria in clean water in urs. The expression "hibernation" has been much used in the U.S.A. and Canada to e the winter condition of oysters on the Atlantic coast; but it is somewhat misleading, as it o give the impression that filtration processes are so slowed down as to be negligible in their In fact it has been observed that oysters in pits at Paglesham are open and passing a weak tectable current in the depths of winter.

conception that there are temperatures at which oysters will cleanse themselves and others, at which they are unable to do so, appears to be fundamentally unsound. The processes result in contamination are identical with those that result in purification; both depend upon action in the gills, the mantle cavity and in the gut. The relations between temperature and action were worked out by Gray (1928), and much subsequent experimental work with intact cs (see Verwey, 1952, for a review of the literature) has confirmed his conclusions.

llows, therefore, that in considering cleansing of oysters in relation to low temperature, all mains to be decided is the time necessary to allow for the elimination of the small amount ution taken in by oysters living under normal conditions. The experiments described above hat four days provides an ample margin of safety even at temperatures approaching zero rade.

The reasons why a full understanding of the winter behaviour of oysters was not reached i early cleansing experiments at Conway can be deduced from the notes left, and by discussion those associated with Webb in his work. At first the polluted oysters used in the trials obtained from a consignment laid in the Conway estuary. During the winter it was found these oysters were not highly polluted in a situation known to be exposed to serious contamina and it was considered that they were unsuitable for experiment. It was concluded that oy behaved capriciously in regard to the amount of pollution they acquired. In reality these oy were apparently showing the normal seasonal fall in degree of pollution. For subsequent ex ments, oysters were placed in a small tank at Conway with a substantial amount of a crude se effluent collected from a nearby outfall. In these circumstances, which are not paralleled in na they became and remained heavily polluted. It is possible also that confinement with st effluent may have affected their subsequent behaviour. Clearly, the behaviour of oysters under such unnatural conditions is not the same as their natural behaviour on the beds, an technique necessary to free them from pollution is difficult, nor can it be said that it is necessa adopt such a technique to deal with oysters polluted in their normal habitat. Indeed, the ex ments detailed above show that oysters, as much as mussels, free themselves very rapidly sewage pollution given conditions in which heavy re-infection is impossible.

6. SUGGESTED PURIFICATION TECHNIQUE

Pits may be of any convenient size, but the depth of water should not exceed 2 ft. nor than 1 ft. Where saltings are available at high water, pits can be excavated convenient lined round the side with boards; elm is most suitable and durable. The bottom of the p be made of rammed chalk, or bricks without jointing material. Shell gravel laid direct on cla however, suffice, but pits with such a bottom are not easy to clean and fresh gravel must be after each cleansing. Where no saltings are available pits may be made of concrete, and in areas it will usually be more convenient to build them out of reach of the tide, and to fill by of a pump. Where pits are made in the saltings, a clay bank should be constructed all ro seaward side so as to exclude the tide, and a sluice should be provided to allow the entry o when required, into a gully feeding the pits.

Pits should be sited as far away from sewer outfalls as is reasonably practicable, and for pre in localities where pollution is reduced substantially at high water. This is the normal co on British oyster beds, but in one or two localities, e.g., in the River Lynher, Plymouth, the po is not reduced at high water as it backs up with the tide from large outfalls below the oyster In such localities and in situations where, for special reasons such as convenience to ports of la it is desired to construct purification pits in close proximity to sewer outfalls, it is recommende the incoming water should be chlorinated. It must also be de-chlorinated after standing fo less than three hours, and this is most easily effected by adding sufficient sodium thiosulphate (in solution to discharge all the chlorine added. The thiosulphate may be sprinkled on the su of the tank with a watering can or, where a storage pit and cleansing pits are available, add the water as it runs from one pit to another.

Oysters may be placed thickly on the bottom of the pit, but in a single layer. They may be placed on wooden slatted grids similar to those used in mussel purification, or directly c bottom. There is no evidence to suggest that grids are necessary or that there is any likel of secondary contamination from the bottom mud when the oysters are lifted off the bo Bacteria contained in extruded faeces or pseudo-faeces are tightly bound with mucus. It is po that this mucus exerts a bacteriostatic effect; liberation of bacteria has not been observed to It may be convenient to place oysters in wooden trays with slatted or woven wire bottoms, wire is used it should not be galvanized as this becomes toxic in stagnant water. Such tray be lifted out as required.

It is recommended that oysters should remain in the pits for four days before marketi order to provide a substantial margin of safety against the occurrence of oysters which are slu in filtration; no such oysters have been encountered in experiments, except when dying result of long exposure to very low water temperatures, but experience has shown that in m the filtering rate may be affected by rough handling and disease. No fresh polluted oysters s

led to the pit during cleansing, but after cleansing and in cool weather, oysters may remain indefinitely in the pits pending marketing.

ormal practice, before placing oysters in storage pits, they are freed from mud and cleaned bulk of the ascidians, barnacles and tube-worms which may grow on their shells, and it is mended that this practice should be followed in cleansing. When the oysters are raised from s a " didal " may be used or the pits may be run off. If they are refilled with sea water, and ıation is not being employed, they must remain undisturbed for another two days before rther oysters are marketed. Since the oysters are clean when the sea water enters, this reduced amply suffices to remove any small amount of contamination that may be brought in with ı water. If trays are used, running off of the water in the pits may be avoided even though stantial number of oysters is required for marketing. Oysters lifted from the pit should sed in a wire basket in a tub of pit water. If a portable motor pump is available the oysters e hosed and the used water allowed to run to waste. Alternatively a special pit may be kept shing, but if the water is not chlorinated (this is essential if there is serious pollution at high , it should be allowed to stand for at least four days before use. During this period the f the faecal *B. coli* it may contain will die (Vaccaro *et al.*, 1950).

recommended that oysters should be packed in wooden barrels or boxes without additional ıg material. If seaweed is used in packing it must be gathered in a locality remote from ›urce of pollution; but it is better avoided. Labels on the barrels should show the number ade of oysters they contain, the date of despatch and their origin.

e oysters may be required daily to meet orders, it will be convenient in most cases to sub- the cleansing pit, or in a large establishment to provide two or more pits. One of the major tages of the system described is that the same pits will suffice for both cleansing and storage. cases of prolonged storage, it is desired to change the water in the pits, this may be effected at nvenient time, provided that two days are allowed to elapse after refilling and before any s are removed for marketing.

7. SUMMARY

oysters (*Ostrea edulis*) and Portuguese oysters (*Gryphaea angulata*) have been shown to purify elves in simple pits filled with seawater, without previous chlorination or other form of ation, and at all temperatures between — 1° and 25·2° C. A satisfactory standard of purity chieved after 48 hours and in the great majority of experiments *B. coli* were absent in 1 ml. ter flesh after four days' treatment.

ally satisfactory results were achieved in pits at Paglesham, where pollution is very light, and nham, where contamination is more serious and where a Closing Order has been made under iblic Health (Shellfish) Regulations, 1934.

st of the experiments were made at periods of neap tides when the pits were isolated, but a at were made at spring tides, when water from the river entered the pits at each tidal period, ave satisfactory results.

ial pollution of oysters taken from near a sewer outfall varied substantially during the year, to a very low level during January and February, when sea temperatures were at their um.

mple technique is described for the cleansing of oysters for market. The capital and running of the installation are very low.

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